LIVESTOCK VS. GRAIN FARMING

OHIO
Agricultural Experiment Station

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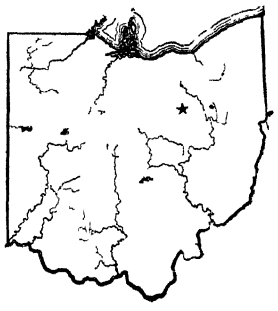

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BULLETIN
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NUMBER 328 JULY, 1918

LIVESTOCK VS. GRAIN FARMING

C G WILLIAMS

The relation of livestock to fertility has ever been an important one. It is a generally accepted fact that the farms in a given community which have the most livestock produce the largest crops. When livestock is not kept in any extensive way, naturally the greater part of the products of the farm must be sold, and unless some provision is made to make good the drain upon the land it cannot be expected that fertility will be maintained. It must be admitted that in most instances adequate provision is not made. Moreover, the feeding of the great bulk of the crops to livestock and the careful utilization of the manure will not maintain fertility save when concentrated feeds are purchased and fed in a large way, or other replacement is made of the mineral elements carried away in animal products and carcasses.

What are the probabilities of maintaining fertility in the State and Nation by the utilization of the manure products of our livestock? There was in the United States in 1910, according to the Thirteenth Census, the equivalent of 96,910,102 head of cattle, if 10 sheep or 10 hogs are regarded equivalent to one horse or cow for fertility maintenance. The same census reports 878,798,325 acres of farm lands in the United States. There is, therefore, the equivalent of one animal of the horse or cattle kind to furnish manure for the maintenance of the fertility of 9.07 acres.

In the state of Ohio there was the equivalent of 3,472,160 head of cattle for 19,227,969 acres of improved farm lands, or one animal for 5.54 acres. The complete figures will be found in Table I.

The impossibility of maintaining fertility under these conditions without recourse to outside sources will at once be granted. Shall the farmer, then, be encouraged to keep more livestock? In the face of these strenuous times when large populations are either

starving or bordering dangerously near the line of starvation, it may not behoove one to insist on this innovation, for cereal grains will go farther as human foods when used directly than when fed to livestock. It is probable that any important change in the number of food-producing animals kept is both unwise and unlikely. Tendencies seem to be in the direction of fewer cattle per capita, of all kinds, rather than of more. Prof. H. W. Mumford, of Illinois, says that "although the cattle of the United States have increased numerically by decades up to the present time, with the probable exception of the last few years (date of circular, 1913) their number has not kept pace with the growing population during the last two ten-year periods."[1]

TABLE I.—LIVESTOCK ON FARMS IN UNITED STATES AND IN OHIO
(Census of 1910)

Livestock		United States	Ohio
Cattle		61 803,866	1,837,607
Horses		19 833 113	910,224
Mules		4 209,769	22,850
Swine		58 185,676	3,105,627
Sheep		52,447,861	3,909,162
Cattle equivalent		96,910,102	3,472,160
Farm lands	acres	878,798,325	19,227,969
Farm land per cow	do	9.07	5.54

It remains, then, to devise systems of grain or vegetable farming which will maintain fertility. In view of the growing interest in systems of farming which do not call for the feeding of crops to livestock for the sake of returning the manure made to the farm, this Station started an experiment in 1910 which it has termed "Livestock vs. Grain Farming." The experiment has not yet been in operation long enough to give much information upon this question, but it may not be out of place to put on record the plans on which the experiment is being conducted, and to make a progress report to date.

PLAN OF THE EXPERIMENT

A uniform tract of 9 acres was divided into equal parts, one-half of which is farmed in livestock, the other in grain farming. The crop rotation followed in this experiment is corn, soybeans, wheat and clover, each crop being grown every year. In the livestock system all the crops grown except the wheat and the clover seed, when a seed crop is harvested, are either fed to livestock or

[1]Ill Agr Exp Sta Cir 169 (1913), p 9

pass into the manure as bedding. This includes the corn stover, wheat and soybean straw, and clover hay.

The livestock is kept in a large box stall, heavily bedded on a cement floor under cover so that all the manure, both solid and liquid, is saved. The stable is not cleaned until the feed is exhausted, when the manure is hauled to the field and spread. The manure made each year from the 4 areas of corn, soybeans, wheat and clover in livestock farming goes on the corn area the following spring. Each livestock tract accordingly receives an application of manure every 4 years. The amount of the application depends upon the size of the crops of the preceding year.

In the grain farming the corn crop is not cut. The ears only are removed, the stover being left on the ground to be plowed under the following season for soybeans. The soybeans and wheat are cut and threshed. The soybean straw, together with a small part of the wheat straw, is spread in early winter on the tract which produced it (in wheat). The rest of the wheat straw is spread during the winter upon the tract which is to go in corn the following year. No clover is cut for hay but it is all devoted to soil improvement. Some seasons the first crop of clover has been cut a little early and left on the ground. Of late the practice has been to allow the first crop to stand without mowing, as there seems to be less loss of organic matter. The plan permits the removal of a second, or seed, crop, with the return of the clover haulm, but to date there has not been a seed crop which justified the labor of harvesting. All the grain and seed crops of this rotation are sold. Nothing is fed to livestock and consequently no manure is made or used. With the season's clover crop and the wheat straw, there has been about all the vegetable matter that could well be plowed under for corn.

Aside from the use of manure in the livestock farming, and the use of all the roughages, including the hay, in the grain farming, both areas are treated alike. Both tracts going in corn receive an application of 400 pounds of 16-percent acid phosphate and 2 tons of ground limestone per acre. Both wheat tracts receive 300 pounds of acid phosphate per acre. There is a tile drain crossing each area every 36 feet. They are both plowed and fitted together, and the same varieties and seed mixtures are used on both.

RESULTS OF THE EXPERIMENT

THE CORN CROP

The first crop of corn was grown on Section B in 1910. The livestock half was given 8 tons of manure per acre. The grain-farming half had not received the previous year's clover crop.

There was a good rye sod on it, however, and it received the phosphatic fertilizer, as did also the livestock half. Beginning with Section C, in 1911, a full year's clover crop was left on the ground for the grain-farming corn.

The yields of corn under the two systems of farming for the 8-year period ended in 1917 are recorded in Table II.

TABLE II.—CORN IN LIVESTOCK AND GRAIN FARMING

Year	Section	Yields per acre				Gain or loss ( ) for livestock farming
		Livestock farming		Grain farming		
		Grain	Stover	Grain	Stover	
		Bu.	*Lb.*	*Bu.*		*Bu.*
1910	B	39.36	2,763	26.61	None harvested	12.75
1911	C	79.33	3,285	72 55		6.78
1912	D	53.48	2,795	37.15		16.33
1913	A	75.15	2,837	74.84		.31
1914	B	65.63	3,218	67.49		—1.86
1915	C	65.19	3,600	62.77		2.42
1916	D	58.52	2,534	50.25		8.27
1917	A	79.95	4,033	76.87		3.08
8-year average		64.58	3,133	58.57		6.01

The stover yields cannot, of course, be given for the grain-farming half as the stover is not harvested.

The final column gives the gain each year of the livestock over the grain-farming system. With the exception of one season the livestock farming has shown a gain, the average being 6.01 bushels per acre, or 10.2 percent.

Three sections, C, D and A, have received two full treatments of manure, or clover and crop residues. It will perhaps give a little information as to the early tendencies of the two systems to compare the yields of these three sections for the two periods. The average gain of the livestock system over the grain farming for the first period, 1911-13, is 7.81 bushels per acre, or 12.7 percent. For the second period, 1915-17, it is 4.59 bushels, or 7.3 percent. This is a falling off of some moment, though time will be required to determine whether it is permanent.

The behavior of Section B may also be significant. It was to be expected that the first corn crop would favor the livestock system, for there had been no clover and residues treatment; but a full course of these treatments makes an important change, apparently, and this is fairly well confirmed by the succeeding crop in the rotation—soybeans.

The excessive gain on Section D in 1912 would seem to indicate that the land of the livestock half was naturally a little superior to

the grain-farming half. If such is the case, it is apparently slowly being overcome, as witness the corn crop of 1916 on D, as well as the soybean crops of 1913 and 1917.

THE SOYBEAN CROP

The first crop of soybeans reported was grown on Section B in 1911. The grain-farming half of this section, it should be noted, did not receive the clover treatment in 1910, but it had a good growth of corn stover plowed under for the soybeans, which evidently was of some benefit. The yields of beans and straw under both systems of farming, as well as the annual gain or loss, are given in Table III.

TABLE III.—SOYBEANS IN LIVESTOCK AND GRAIN FARMING

Year	Section	Yields per acre				Gain or loss (—) for livestock farming
		Livestock farming		Grain farming		
		Seed	Straw	Seed	Straw	
		Bu.	*Lb.*	*Bu.*	*Lb.*	*Bu.*
1911	B	27.26	1,463	22.51	1,210	4.75
1912	C	28.58	2,180	25.33	2,011	3.25
1913	D	19.89	1,668	15.48	1,373	4.41
1914	A	18 51	1,901	19.13	1,869	—.62
1915	B	20.13	2,104	18.67	1,756	1.46
1916	C	20.49	2,112	16.47	1,989	4.02
1917	D	18.33	2,491	15.37	2,027	2.96
7-year average		21.88	1,988	18.99	1,748	2.89

The yields of soybeans were much greater the first 2 years than they have been since. This fact is doubtless due to seasonal variations. The soybean is peculiarly sensitive to seasonal conditions. There is no evidence of any decline in the productive ability of this land in the corn or wheat yields.

With one exception the livestock system has led each year. Section A in 1914 showed a slight gain for grain farming. This is not the section which showed a small gain for grain farming in corn, though the year previous the livestock system led by less than one-third of a bushel of corn on Section A, which is for all practical purposes a tie.

The 7-year average gain for livestock farming is 2.89 bushels of soybeans per acre, or 15.2 percent. This is a larger gain than was found in the corn crop. In yield of straw the livestock farming leads by 240 pounds per acre, on the average, or 13.7 percent.

In attempting to discover the tendencies of the two systems as indicated by the soybean crop, it will perhaps be as well to compare

the first 3 years with the last 3 years. The average gain for livestock farming for the first period is 4.14 bushels per acre, or 19.6 percent; for the second period it is 2.81 bushels, or 16.7 percent.

THE WHEAT CROP

The results with wheat are recorded in Table IV. Owing to the late wheat seeding in the fall of 1911 and the unusually severe winter following, the wheat crop which should have been harvested in 1912 was destroyed and the land was seeded to oats in the spring of 1912. The figures for 1912 in the table are accordingly oat yields.

The average gain for livestock farming in the six crops of wheat harvested is 3.66 bushels per acre, or 12.7 percent. In straw the gain is 470 pounds per acre, or 17.8 percent. If the full period is divided into two equal parts the gain in favor of livestock farming for the first 3 years is 4.41 bushels, or 18.4 percent, and for the second 3 years is 2.92 bushels, or 8.7 percent.

The wheat crop, like the corn crop, seems to show a marked falling off in the lead of the livestock system.

TABLE IV.—WHEAT IN LIVESTOCK AND GRAIN FARMING

Year	Section	Yields per acre				Gain for livestock farming
		Livestock farming		Grain farming		
		Grain	Straw	Grain	Straw	
		Bu.	*Lb.*	*Bu.*	*Lb.*	*Bu.*
1911	A	23.98	1,791	20.83	1,645	3.15
1912*	B	48.48	1,719	38.17	1,259	10.31
1913	C	27.83	2,571	23.59	2,041	4.24
1914	D	33.21	3,592	27.37	2,937	5.84
1915	A	38.45	3,992	35.13	3,510	3.32
1916	B	34.42	3,410	30.94	2,913	3.48
1917	C	36.33	3,303	34.38	2,794	1.95
6-year average		32.37	3,110	28.71	2,640	3.66

*The yields for 1912 are for oats. See text for explanation.

THE CLOVER CROP

The conditions of this test confine the weighed yields of clover hay to the livestock half, as the grain-farming clover is not gathered. The figures recorded in Table V are for one cutting in every instance.

The range in yield is from 1.42 tons per acre to 3.3 tons, the 8-year average yield being 2.23 tons. The largest yields of clover were harvested on Section C in 1910, and on Section A in 1912 and 1916. It is worthy of note that each of these three large clover

crops was followed by exceptionally large corn crops the next year in both systems of farming.

TABLE V.—CLOVER IN LIVESTOCK FARMING

Year	Section	Yield per acre
		Tons
1910	C	2.86
1911	D	2.00
1912	A	3.30
1913	B	1.55
1914	C	1.84
1915	D	1.42
1916	A	2.86
1917	B	2.03
8-year average		2.23

A STUDY OF THE SECTIONS

It may perhaps turn some light upon the question under consideration to arrange these data by sections as well as by crops. In Table VI the data given in previous tables are accordingly arranged by sections and show both the bushel and the percentage gain or loss of livestock as compared with grain farming for each year. For instance: Section A was in wheat in 1911, and the yield of grain from the livestock half was 3.15 bushels, or 15.1 percent, greater than from the grain-farming half. Wheat is always followed by clover in this experiment but a comparison of the two systems cannot be made for the clover year as the grain-farming clover is not harvested. Hence there is a skip of 1 year, the next crop on Section A being corn in 1913.

The crops on each section are divided into two periods. On two sections six crops have been harvested (the clover crops are omitted), which make an easy division of three crops in each period. On the other two sections only five crops have been harvested. The middle crop has therefore been omitted and only the two crops used which have been grown in both periods.

In computing the average percentage of gain, recourse is had to the actual yields of the several crops as recorded in the earlier tables, which have been reduced to pounds.

In considering Section A it will be noted that the second crop of wheat shows a percentage decline in the lead of livestock farming, while the second crop of corn shows the reverse. The livestock half has increased its gain from 3.8 percent in the first period to 5.8 percent in the second.

Section B starts off with the one crop of which the grain-farming half does not have the benefit of clover, and the livestock

farming leads by a large percentage, which is not lost until the second corn crop is harvested on this section, despite the fact that good crop residues of corn stover and soybean straw were used. The decline in the lead of the livestock half during the second period is decisive, though not especially surprising.

TABLE VI.—GAIN OR LOSS FOR LIVESTOCK FARMING ARRANGED BY SECTIONS

Section A				Section B			
Year	Crop	Gain or loss (—)		Year	Crop	Gain or loss (—)	
		Bu.	*Percent*			*Bu.*	*Percent*
				1910	Corn	12.75	47.9
1911	Wheat	3.15	15.1	1911	Soybeans	4.75	21.1
1913	Corn	.31	.4	1912	Oats	10.31	27.0
1914	Soybeans	—.62	—3.2	1913	Corn	—1.86	—2.8
1915	Wheat	3.32	9.4	1915	Soybeans	1.46	7.8
1917	Corn	3.08	4.0	1916	Wheat	3.48	11.2
Average gain for first period			3.8	Average gain for first period			32.7
Average gain for second period			5.8	Average gain for second period			2.8
Section C				**Section D**			
1911	Corn	6.78	9.3				
1912	Soybeans	3.25	12.8	1912	Corn	16.33	44.0
1913	Wheat	4.24	18.0	1913	Soybeans	4.41	28.5
1915	Corn	2.42	3.9	1914	Wheat	5.84	21.3
1916	Soybeans	4.02	24.4	1916	Corn	8.27	16.5
1917	Wheat	1.95	5.7	1917	Soybeans	2.96	19.3
Average gain for first period			11.9	Average gain for first period			39.2
Average gain for second period			7.5	Average gain for second period			17.1

Combined average gain for livestock farming for all four sections:

	Percent
Average gain for first period	18.2
Average gain for second period	7.2

Section C has behaved quite consistently with the exception of the soybean crop of 1916. With the two crops of corn and wheat there is a decided decline in the lead of the livestock half in the second round, but the opposite is true of the soybean crop. As an average of the two periods, there is a slight decline.

On Section D the livestock system had a decided lead at the start. This is reduced in the case of the two crops with which comparison is possible. Corn declines from a gain of 44 percent in favor of livestock farming to a gain of 16.5 percent, and soybeans from 28.5 percent to 19.3 percent. For the two periods the decline is important.

At the bottom of Table VI the averages of the first and second periods for all four sections are combined in one general average, which shows a gain for the livestock system of 18.2 percent for the first period and 7.2 percent for the second period.

RELATIVE PROFITS OF LIVESTOCK AND GRAIN FARMING

The writer will not attempt at this time to determine the relative profits of livestock and grain farming. The profits of livestock farming depend largely upon the skill of the buyer or breeder and the feeder. While an accurate record was kept of the weights and gains of the animals fed in this experiment, the animals used were not such as would show the greatest profit from the use of the feed. It was the fertility and crop production side of the problem that was uppermost in mind. It should not be a difficult matter for an experienced feeder to decide what livestock gains and profits are to be expected from a given amount of feed. The average data of many feeding tests should be more conclusive at any rate than any data likely to be secured in one test.

The question whether it is more profitable to sell corn, oats and soybeans directly or to market them through livestock cannot be answered off hand. It involves something more than a knowledge of the gains and profits of feeding livestock and the cash price of cereals and legumes, together with the comparative labor expense of the two systems of farming. The farmer may decide that he is taking a chance in feeding livestock with the price of corn where it now is and decline to take the chance. If most livestock farmers were to make this decision, only one thing could happen: Our largest market for corn would be wiped out; for, according to the best statistics obtainable, fully 82 percent of the corn crop of the United States is fed to livestock and only about 8 percent is used for human food. With the main market for corn destroyed, the price of cereals would not long remain at a point which would make grain farming profitable.

LABOR REQUIRED IN LIVESTOCK AND GRAIN FARMING

It is of interest to compare the amount of labor in the two systems of farming. Many of the operations will be the same in both systems, such as the preparation of seed bed, planting, cultivating, and the harvesting and threshing of the soybeans and wheat. The harvesting of the corn crop will be quite different, as also the handling of the clover and the hauling and spreading of the manure. Some of the operations which differ quite a little may be regarded as offsetting each other, the labor difference being so slight. The handling of the corn crop will perhaps prove most difficult of adjustment. The livestock farmer may cut and shock his corn, husk and crib the grain, tie and reshock the stover, then haul to the barn; he may omit the husking of the corn, feeding it directly from the

shock; he may run the corn through the silo, or he may hog down a good part of his corn. In the last event the picking and cribbing of the corn in the grain-farming system would prove much more expensive. But if the first plan is followed, the husking and handling of the stover would be the more expensive operation, to say nothing of the cutting and shocking of the corn. It is probable that this operation should be charged against the livestock system.

In the grain farming there is the handling and spreading of the soybean and wheat straw on the land and the hauling of the corn to market. It will not be far amiss to let this work offset the running of the straw through the stable and the feeding of the corn to livestock. There is the same handling in either case. While the daily feeding and bedding of livestock is more confining, even in grain farming there will be some daily chores which must be attended to, as a rule, and a little more or less is not especially important. The time may be near at hand when the grain farmer will use petroleum power exclusively and thus be able to spend his winters in California or Florida. When this time comes the offset mentioned may not be in order.

Taking up the items which probably should be charged against livestock farming, we have the hauling of manure, the cutting and shocking of the corn crop and the harvesting of the clover. In determining the cost of the first two items perhaps the best data available are to be found in Bulletin 266 of the Ohio Station.[1] Figures were secured from a large number of Ohio farms, involving several hundred acres. With small fractions omitted, the labor charge per acre would be about as follows:

Operation	Man hours	Horse hours
Cutting and shocking corn	9	..
Hauling and spreading manure	12	18
Making clover hay	8	8

As applied to the rotation followed in the experiment above reported, this labor charge is for a full rotation period. It should be divided by 4 to get the average annual charge per acre.

It is proper to call attention to the extra equipment in the way of buildings, etc., necessary in livestock farming. This, of course, will vary widely and it is perhaps useless to attempt to estimate it.

THE PRODUCTION OF MANURE

In the original planning of this test it was not thought that feeding to livestock the actual or equivalent amount of crops harvested from the livestock half would be necessary to determine

[1] *Labor Cost of Producing Corn in Ohio*, L. H. Goddard and W. L. Elser

the amount of manure to which the livestock corn crop was entitled each year. This Station had secured accurate data as to the recovery of the nitrogen, phosphorus and potassium in feedstuffs in manure.[1] It seemed a comparatively easy matter to determine the amount of nitrogen, phosphorus and potassium in the crops grown, and then by using the data above mentioned to determine the amount of these elements one would expect to find in the manure, provided the crops had been fed, to weigh out the necessary amount of manure.

For instance, it was found one season that the crops harvested should carry 212.76 pounds of nitrogen, 30.62 pounds of phosphorus and 196.53 pounds of potassium. According to earlier experiments, the feeder should expect to recover in the manure 74.7 percent of the nitrogen, 77.5 percent of the phosphorus and 87.8 percent of the potassium. As analyzed by this Station, 15.4 tons of manure would be required to furnish the necessary nitrogen; 7.3 tons to furnish the phosphorus and 21.2 tons to furnish the potassium. It was accordingly apparent that if any high degree of accuracy was to be secured it would be necessary to feed the crops produced to livestock and use the resultant manure.

Beginning with the crops grown in 1913, the corn and stover, soybeans and soybean straw, wheat straw and clover hay produced on the livestock half have been fed to livestock or used as bedding during the winter, and the manure made from the four areas has been spread on the area going in corn the following spring.

The weight of manure made varies with the size of the crops grown, with the water consumed by the livestock, the length and time of year of the feeding period, and perhaps other factors. Reference to Tables II to V, inclusive, will show the feed used in the production of the amounts of manure recorded. The crops grown in 1913 were fed to seven 2-year-old Angus heifers and one bull, in a feeding period extending from January 16 to April 23. The manure produced was at the rate of 13.55 tons per 4 acres of crops. The crops of 1914 were fed to four steers from January 5 to May 5. The manure produced was at the rate of 10.89 tons per 4 acres. The crops of 1915 were fed to seven heifers, the test beginning December 21 and ending March 21. The manure product was 14.89 tons per 4 acres. The crops of 1916 were fed to twelve calves and two bulls, the test beginning December 22 and ending April 2. The manure product was 14.06 tons per 4 acres.

[1]Ohio Agr. Exp. Sta. Bul. 183 (1907), p 199

The amount of manure produced has been quite uniform save for the crop year of 1914, when it was 2.46 tons below the 4-year average. This lower yield of manure can hardly have been due to a difference in food products. It was apparently a matter of moisture content. The manure was noticeably very dry when hauled, weighed and spread, considerably drier than usual. This was due to the long and late feeding period. Unfortunately the manure was not sampled for the year in question. The moisture content other years of the test has ranged from 72.89 to 78.82 percent.

The average amount of manure produced has been 13.35 tons per 4 acres, or 3.34 tons per acre annually. This makes a good application every 4 years. These figures are a guide as to what may be expected in the matter of manure production in livestock farming on land of this degree of fertility when all the grain crops except wheat are fed.

THE MAINTENANCE OF NITROGEN

It is of interest to determine the nitrogen balance in the two systems of farming compared in this experiment. Under the system of grain farming the average yields per acre for the period of the test are as follows:

Corn	58.6 bushels
Soybeans	19.0 "
Wheat	28.7 "
Clover (estimated)	2.75 tons

The yield of clover in the grain farming must be estimated, since it is not harvested. If the grain farming clover bears the same relation to the livestock clover that the other crops of the rotation do, there should have been 2 tons of clover hay per acre. It is proper to add to this three-fourths of a ton for extra summer, fall and spring growth, making the total as above.

As handled in this test two of the crops will result in a loss of nitrogen to the soil, and two in a gain. The 58.6 bushels of corn will remove from the soil nearly 58 pounds of nitrogen, and the 28.7 bushels of wheat, 34 pounds. As the stover and straw are returned to the soil, the total loss of nitrogen in the cereal crops is 92 pounds.

In the case of the soybean crop, the 19 bushels of seed will carry 62 pounds of nitrogen, and the 1,728 pounds of straw, 35 pounds, or 97 pounds of nitrogen in seed and straw. There remain the stubble and roots to account for. Experiments show that about one-tenth of the total nitrogen in the soybean plant is in the roots and

stubble.[1] There will therefore be 11 pounds to add to the figure above, making a total of 108 pounds of nitrogen for an acre of soybeans. The question arises, How much of this nitrogen was drawn from the soil and how much from the air? The best data available indicate that about "one-third of the nitrogen contained in legume plants is taken from the soil and not more than two-thirds from the air."[2] Of this 108 pounds of nitrogen 72 pounds, then, may be credited to the air and 36 pounds to the soil. Since the straw, roots and stubble carry 46 pounds of nitrogen and are left on and in the soil, there is a gain to the soil of 10 pounds of nitrogen per acre as a result of growing the crop, notwithstanding that 62 pounds of nitrogen is sold in the soybean seed.

The 2.75 tons of clover will carry 120 pounds of nitrogen, and the roots and stubble, 60 pounds more,[3] or a total of 180 pounds. Of this amount 60 pounds is figured as coming from the soil and 120 pounds from the air. Since the entire crop is devoted to soil improvement, the soil gains 120 pounds of nitrogen per acre.

The nitrogen account in the grain-farming system then stands as follows:

	Pounds
Loss of nitrogen per acre per rotation	
Corn crop	58
Wheat crop	34
Total	92
Gain of nitrogen per acre per rotation	
Soybean crop	10
Clover crop	120
Total	130
Net gain per acre per rotation	38

In striking a nitrogen balance in the livestock farming, when the yields recorded in Tables II-V and the average analyses made by this Station (See Table VII) are used, there is a loss to the soil in the total crops of corn and wheat, and one-third of the legume crops—the proportion estimated to be derived from the soil—of 247.02 pounds of nitrogen. There is returned to the soil in 13.35 tons of manure, as shown by the Station analyses, 15.4 pounds of nitrogen per ton, or 205.59 pounds; and in the roots and stubble of the soybean crop, and the estimated second crop, roots and stubble of the clover crop, 110.67 pounds, or a total of 316.26 pounds of nitrogen. This leaves a balance of 69.24 pounds as shown by the following:

[1] C. G. Hopkins, *Soil Fertility and Permanent Agriculture*, p. 223.
[2] Ibid, p. 217.
[3] Ibid, p. 223.

Loss of nitrogen per acre per rotation	Pounds
Corn (grain and stover)	88.10
Wheat (grain and straw)	52.81
Soybean crop (one-third)	41.10
Clover crop (one-third)	65.01
Total	247.02
Gain of nitrogen per acre per rotation	
13.35 tons of manure	205.59
Soybean roots and stubble	12.30
Clover (2d growth and residues)	98.37
Total	316.26
Net gain per acre per rotation	69.24

The nitrogen balance is therefore 31.24 pounds per acre per rotation greater in the livestock than in the grain farming. The average annual difference is 7.81 pounds per acre.

THE ULTIMATE SYSTEM OF FARMING

As the population of the world increases a day may come when it will be necessary to utilize such portions of our cereal crops as can be used for human food directly for this purpose, thus avoiding the serious loss of energy incident to the feeding of livestock of all kinds. What these losses are, Director H. P. Armsby, of the Institute of Animal Nutrition of Pennsylvania, points out in a recent number of *Science*.[1] He says: "It may be roughly estimated that about 24 percent of grain is recovered for human consumption in pork; about 18 percent in milk and only about 3.5 percent in beef and mutton."

The same idea is expressed by Cooper and Spillman in a recent Farmers' Bulletin:[2] An acre of land devoted to the growing of corn, with an average yield of 35 bushels, will produce more than four times as much energy if used directly as a human food than if devoted to pork production in the growing of corn and clover in the most desirable proportions for economic pork production. An acre of wheat, with an average yield of 20 bushels, will furnish more than 13 times as much energy as an acre devoted to beef production.

Evidently the hog will be able to prove his right to a portion of our corn crop for a longer period than will the beef animal, though the larger use by the latter of materials unfit for human consumption—roughages of one kind and another—will give the beef animal a place in our agriculture for a long time to come. Ulti-

[1] Vol. XLVI, No. 1181, p. 160.
[2] U. S. Dept. Agr. Farmers' Bul. 877, p. 4.

mately livestock farming may be expected to give place to grain and vegetable farming on a large part of our farm lands. As a matter of fact this has already happened on extensive areas. Such changes should and will come about very gradually. It is none too soon, however, to work out plans whereby the fertility of the soil may not only be maintained but increased under such conditions.

TABLE VII.—PERCENTAGE COMPOSITION OF OHIO FARM CROPS
Expressed as elements and oxides

Crop	Nitrogen (N)	Phosphorus (P)	Phosphoric acid (P_2O_5)	Potassium (K)	Potash (K_2O)	Calcium (Ca)	Calcium oxide (CaO)
Wheat	1.975	0.3486	0.7986	0.3547	0.4270	0.0357	0.050
Wheat straw	.528	.0908	.2081	.8304	1.0000	.1929	.270
Oats	2.012	.4095	.9381	.5789	.6970	.0786	.110
Oat straw	.581	.0875	.2005	1.0947	1.3180	.3574	.500
Corn	1.758	.2391	.5480	.3402	.4090	.0214	.030
Corn stover	.814	.0667	.1530	.7795	.9390	.3658	.512
Corncobs	.500	.0261	.0600	.6393	.7700	.0571	.080
Clover hay	2.167	.1829	.4190	1.3367	1.6100	1.4293	2.000
Timothy hay	.841	.1308	.3000	1.1242	1.3540	.2281	.319
Alfalfa hay	2.510	.2901	.6640	1.6600	2.0000	1.5070	2.110
Potatoes	*.340	*.0700	*.1600	*.4810	*.5800	*.0210	*.030
Soybeans	5.430	.6270	1.4340	1.8700	2.2500	.1860	.260
Soybean straw	2.000	.0686	.1570	.6810	.8210	*1.0430	*1.460

PLANT FOOD REMOVED PER ACRE BY OHIO CROPS WITH YIELDS AS ESTIMATED—Pounds

Crop	Yield per acre	Nitrogen (N)	Phosphorus (P)	Phosphoric acid (P_2O_5)	Potassium (K)	Potash (K_2O)	Calcium (Ca)	Calcium oxide (CaO)	Weight of crop
Wheat	25 bu.	29.62	5.23	11.98	5.32	6.40	0.53	0.75	1,500
Wheat straw	3 000 lb.	15.84	2.72	6.24	24.91	30.00	5.79	8.10	3,000
Oats	50 bu.	32.19	6.55	15.01	9.26	11.15	1.26	1.76	1,600
Oat straw	3,000 lb.	17.43	2.62	6.01	32.84	39.54	10.72	15.00	3,000
Corn	50 bu.	49.22	6.69	15.34	9.52	11.45	.60	.84	2,800
Corn stover	3,500 lb.	28 49	2.33	5.35	27.28	32.86	12.80	17.92	3,500
Corncobs	600 lb.	3.00	.16	.36	3.83	4.62	.34	.48	600
Soybeans	22 bu.	71.68	8.28	18.93	24.68	29.70	2.45	3.43	1,320
Soybean straw	2,000 lb.	40.00	1.37	3.14	13.62	16.42	20.86	29.20	2,000
Clover hay	4,000 lb.	86.68	7.32	16.76	53.47	64.40	57.17	80.00	4,000
Timothy hay	4,000 lb.	33.64	5.23	12.00	44.97	54.16	9.12	12.76	4,000
Alfalfa hay	6,000 lb.	150.60	17.41	39.84	99.60	120.00	90.42	126.60	6,000
Potatoes	150 bu.	30.60	6.30	14.40	43.29	52.20	1.89	2.70	9,000

*From average analyses made by the Department of Chemistry of the Ohio Agricultural Experiment Station except those marked with the asterisk.